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PROPOSED METHOD OF MEASURING THE SPIN OF THE K' MESON

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The recent discovery[1] of the K' meson with a mass of about 880 Mev has led to considerable speculation about its role in strange particle reactions. A knowledge of its spin is hence of obvious importance. It has already been verified that the K' has isotopic spin 1/2 and decays via the modes $K' \to K + \pi$. At the moment, one possibility for determining whether its spin is 0 or 1 is by observing the occurrence (or nonoccurrence) of the decay mode $K' \to K + \gamma$. It is the purpose of this note to point out another method of measuring the spin of the K', which, although no better than the above, is rather unique and perhaps somewhat elegant.

The reaction we shall consider is $\bar{p} + p \to K^0 + \bar{K}^{0\prime}$ or $K^{0\prime} + \bar{K}^0$, where the antiproton capture takes place at rest. Only one assumption will be made here—namely that the capture proceeds from an S state. The justification for this assumption rests on the recent arguments of Day, Snow, and Sucher.[2] At any rate, there is an inherent check of this assumption in the experiment as will be seen below.

Subject to the above assumption, the initial state can be either the triplet or the singlet state. The triplet state is odd under charge conjugation and the singlet state is even. The parity of the initial system is odd.

The reaction $\bar{p} + p \to K^0 + \bar{K}^0$. It is well known that if the above conditions are satisfied, then the outgoing $K^0\bar{K}^0$ system must be odd under charge conjugation. If this is so, the outgoing wave function will have the factor $K_{1a}{}^0K_{2b}{}^0 - K_{2a}{}^0K_{1b}{}^0$. Hence one K^0 will always decay via the $K_1{}^0$ mode and the other will decay via the $K_2{}^0$ mode. The observation of this effect serves then as a check on the assumption of S-state capture.

The reaction $\bar{p} + p \to K^0 + \bar{K}^{0\prime}$ or $K^{0\prime} + \bar{K}^0$, in the event that the $K^{0\prime}$ has spin zero. In this case, the outgoing state must be an S state (since the relative parity of the K and K' is odd). Hence the initial state must be the singlet S state. Therefore it is even under charge conjugation. Hence the final state must be of the form $K^0\bar{K}^{0\prime} + K^{0\prime}\bar{K}^0$. The $K^{0\prime}$ (or $\bar{K}^{0\prime}$) decays via the mode

$$K^{0\prime} \to (\tfrac{1}{3})^{1/2}K^0\pi^0 - (\tfrac{2}{3})^{1/2}K^+\pi^-,$$
$$(\bar{K}^{0\prime} \to (\tfrac{1}{3})^{1/2}\bar{K}^0\pi^0 - (\tfrac{2}{3})^{1/2}K^-\pi^+).$$

If we now adopt the notation that subscript a refers to the primary K^0 or $\bar{K}^0$ and b refers to the other, we can rewrite our outgoing state as

$$\psi = \psi_1 + \psi_2 = (\tfrac{1}{3})^{1/2}\left\{\frac{K_a{}^0\bar{K}_b{}^0\pi^0 + \bar{K}_a{}^0K_b{}^0\pi^0}{\sqrt{2}}\right\} - (\tfrac{2}{3})^{1/2}\left\{\frac{K_a{}^0K_b{}^-\pi^+ + \bar{K}_a{}^0K^+\pi^-}{\sqrt{2}}\right\}.$$

We shall deal now only with the first part of this state. Let us substitute

$$K^0 = (K_1{}^0 + K_2{}^0)/\sqrt{2}, \quad \bar{K}^0 = (K_1{}^0 - K_2{}^0)/\sqrt{2}.$$

We then have

$$\psi_1 = (K_{1a}{}^0K_{1b}{}^0 - K_{2a}{}^0K_{2b}{}^0)/\sqrt{2}.$$

Hence we will observe either a two-$K_1{}^0$ type of decay or a two-$K_2{}^0$ type of decay, but no events in which we have both a $K_1{}^0$ and a $K_2{}^0$.

The reaction $\bar{p} + p \to K^0 + \bar{K}^{0\prime}$ or $K^{0\prime} + \bar{K}^0$, in the event that the spin of the K' is 1. In this case the outgoing state must be a p state. Hence we can have either $J = 0$ or $J = 1$. $J = 2$ is forbidden since there is no $J=2$ initial state. The $J=0$ part is even under charge conjugation and the $J=1$ part is odd. Hence we have

$$\psi_1 = A_0\left(\frac{K_{1a}{}^0K_{1b}{}^0 - K_{2a}{}^0K_{2b}{}^0}{\sqrt{2}}\right) + A_1\left(\frac{K_{1a}{}^0K_{2b}{}^0 - K_{2a}{}^0K_{1b}{}^0}{\sqrt{2}}\right),$$

where A_0 refers to the $J=0$ part and A_1 refers to the $J=1$ part.

Turning to the problem of determining the spin of the K', let us first select that group of $\bar{p}$ stoppings which show a $K_1{}^0$ decay with a momentum such that the other outgoing particle is a K' (or $\bar{K}'$) meson. This can be done above background to the extent that the K' mass is well defined. Then we can deduce the following points:

1. If the spin of the K' is zero, then another $K_1{}^0$ decay must also occur.

2. If the spin of the K' is 1, then the other K^0 can decay via the $K_2{}^0$ mode some of the time, unless A_1 happens to be zero.

3. In addition, we can unambiguously determine the spin by considering those cases where both decays are observed to be of the $K_1{}^0$ type. Let us consider the z axis along the direction in which the K' was moving before decay. Events of the above sort must have $J=0$ regardless of the spin of the K'. The orbital angular momentum of the $K\bar{K}'$ (or $K'\bar{K}$) system must have z component equal to zero. Hence the K' must have its spin in the $m=0$ state. If we now consider its decay into π^0+K^0 in its own center-of-mass system, the outgoing particles will have the following distributions about the z direction:

(a) If spin $K'=0$, the distribution is obviously isotropic.

(b) If spin $K'=1$, the distribution must have the form $\cos^2\theta$, where θ is the polar angle between π^0 and K'.

In the event that there is a nonresonant $K_1{}^0K_1{}^0\pi^0$ background, as there most certainly will be, then the distribution which one will obtain as a result of the above procedure will have the form $|\sum\alpha_iP_i{}^0(\cos\theta)|^2$. In principle, one can then determine the coefficients α_i from the distribution and observe whether α_0 or α_1 varies significantly in passing through the resonance. If α_0 varies, then the spin of the K' is zero. If α_1 varies, the spin is 1.

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PION-LAMBDA RESONANCE ($Y_1{}^*$)*

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Alston et al.[1] have discovered an $I=1$ π-Λ resonance with a mass of 1380 Mev and a half-width $\Gamma/2$ consistent with 32 Mev. They reported on 141 $\Lambda\pi^+\pi^-$ events made by 1150-Mev/c K^- mesons incident on the 15-in. Lawrence Radiation Laboratory hydrogen bubble chamber which produced the sequence

$$K^- + p \rightarrow Y_1{}^{*\pm} + \pi^{\mp}, \qquad (1)$$

followed by a strong decay,

$$Y_1{}^{*\pm} \rightarrow \Lambda + \pi^{\pm} + 130 \text{ Mev}. \qquad (2)$$

In the course of a continuing study of K^-p interactions, we have now explored the same reactions from $Y_1{}^*$ threshold [P_K(lab) = 405 Mev/c] through $P_K = 850$ Mev/c. We report on ~500 $\Lambda\pi^+\pi^-$ and find $m(Y_1{}^*) = 1385$ Mev and $\Gamma/2$ closer to 20 Mev;